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A Preliminary Investigation into Responses of Resurrection Fern to Saltwater Inundation

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Salt water inundation from storm surges caused by hurricanes or northeasters is an episodic phenomenon which may have great impact on coastal vegetation community structure (Clark, 1990; Hayden et al., 1991). Recent hurricanes, such as Hugo (1989) and Andrew (1992) produced large storm surges that affected maritime forest for many miles of coastline in the southeastern United States. Although many trees succumbed to extreme physiological stress produced by the overwash (Johnson and Young, 1992), epiphytic species, such as *Tillandsia usneoides* (Spanish Moss) and *Polypodium polypodoides* (Resurrection Fern), also may have been adversely affected. *Polypodium polypodioides* occurs in maritime forests where it is commonly found growing in large colonies on lower branches of *Quercus virginiana* (Live Oak) (Cobb, 1956; Small, 1938).

Dune and maritime forest ecosystems rely on nutrient inputs from salt spray (van der Valk, 1974; Art et al., 1974; Potts, 1976). Furthermore, epiphytic species of maritime forest derive cation minerals from salt spray inputs (Sheline et al., 1976; Schlesinger and Marks, 1977; Benzing, 1978). Although epiphytes are known to rely on nutrient inputs from salt spray, very little is known about responses of epiphytic species to higher concentrations of salinity resulting from inundation. Studies of responses of ferns to salt concentration have been few and generally focussed on terrestrial plants (Medina et al., 1990).

The objectives of this study were to 1) investigate the basic levels of rehydration and photosynthetic responses of unstressed *P. polypodoides* and 2) investigate rehydration of ferns exposed to increasing levels of salinity stress and the effects of prolonged salinity exposure on plant survivorship.

MATERIALS AND METHODS

Clumps of *Polypodium polypodioides* L. were collected from branches of *Quercus virginiana* in a maritime forest near Georgetown, South Carolina (33°22′N, 79°30′W) in August, 1990. Cork substrate was carefully removed so that disturbance of *P. polypodioides* roots and rhizomes would be minimal. In the lab, cork substrate and rhizomes were divided into sections having a minimum of 2 to 3 intact leaves. Each substrate-rhizome section was treated as an individual sample unit.

To quantify length of time needed for hydration under unstressed conditions, 3 replicates, each containing 20 sample units, were placed into clear

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plastic bags, given a 16/8 hr photoperiod, 25/20° C temperature regime and watered with deionized water. Relative humidity within the plastic bags was maintained at approximately 80 percent. Leaf rehydration was monitored at 3 hr intervals for the first two days of the experiment. To quantify gas exchange characteristics of unstressed plants, measurements of CO_2 uptake were made in the lab using a microcomputer controlled infrared gas analysis system (Data Design Group, PacSys 9900) fitted with a clamp on, peltier cooled cuvette (Osborne, 1988). Leaves were brought from darkness (<0.25 μmol m^{-2} s^{-1} Photon Flux Density (PFD)) to saturating PFD with a GE cool beam incandescent light connected to a potentiometer (Osborne, 1988). Darkness was achieved by placing the PacSys 9900 cuvette with contained leaf beneath a black, opaque plastic sheet.

To investigate the ability of leaves to rehydrate in response to salt water inundation, sample units were exposed to treatments of 0, 1, 2.5, 5, 10 or 20 ppt salinity (3 replicates per treatment, 10 sample units per replicate). Procedure of this experiment duplicates those described in the preceding paragraph. Observations of the responses of samples to treatment were made hourly for the first day and then daily for the next 8 weeks.

All observations and manipulations were initially meant to be included as part of a larger study, however, due to shortages of time and equipment and changes in my circumstances, the study had to be curtailed. Therefore, this study, as is, is intended as a descriptive study and not in depth enough for sophisticated statistical manipulation. The data do, however, show responses of this species to salt water inundation in reaction to likely natural events such as hurricane induced storm surges. Therefore, I intend this presentation to spark interest in further investigation.

Results and Discussion

When given only fresh water and allowed to rehydrate in an ambient relative humidity of 80 percent, *Polypodium polypodioides* became fully rehydrated in 12 ± 3 hrs (Fig. 1). CO_2 uptake of fully rehydrated leaves reached a peak value of 5. 000 μmol m^{-2} s^{-1} at an incident PFD of 80 μmol m^{-2} s^{-1} (Fig 2). CO_2 uptake (A) of *P. polypodioides* closely matched values for shade–adapted plants of the terrestrial fern, *Dennstaedtia punctilobula* (Brach et al., 1993). Like *D. punctilobula, P. polypodioides* is probably adapted to utilize sunflecks (Chazdon and Pearcy, 1991). Sunflecks are common throughout the canopy of live oak trees (unpublished data).

In the salt treatment experiment there was an obvious relationship between time taken to rehydrate and concentration of salinity, however, leaves in all treatments rehydrated within a 24 hour period (Fig. 2). Leaf necrosis was evident in the 20 ppt treatment by the second week. In the third week, leaf mortality was nonexistent in 1, 2.5 or 5 ppt salinity concentrations, 10 ± 2 percent in 10 ppt salinity and 30 ± 5 percent in 20 ppt salinity. By the fifth and final week of the experiment, leaf mortality in the 20 ppt concentration

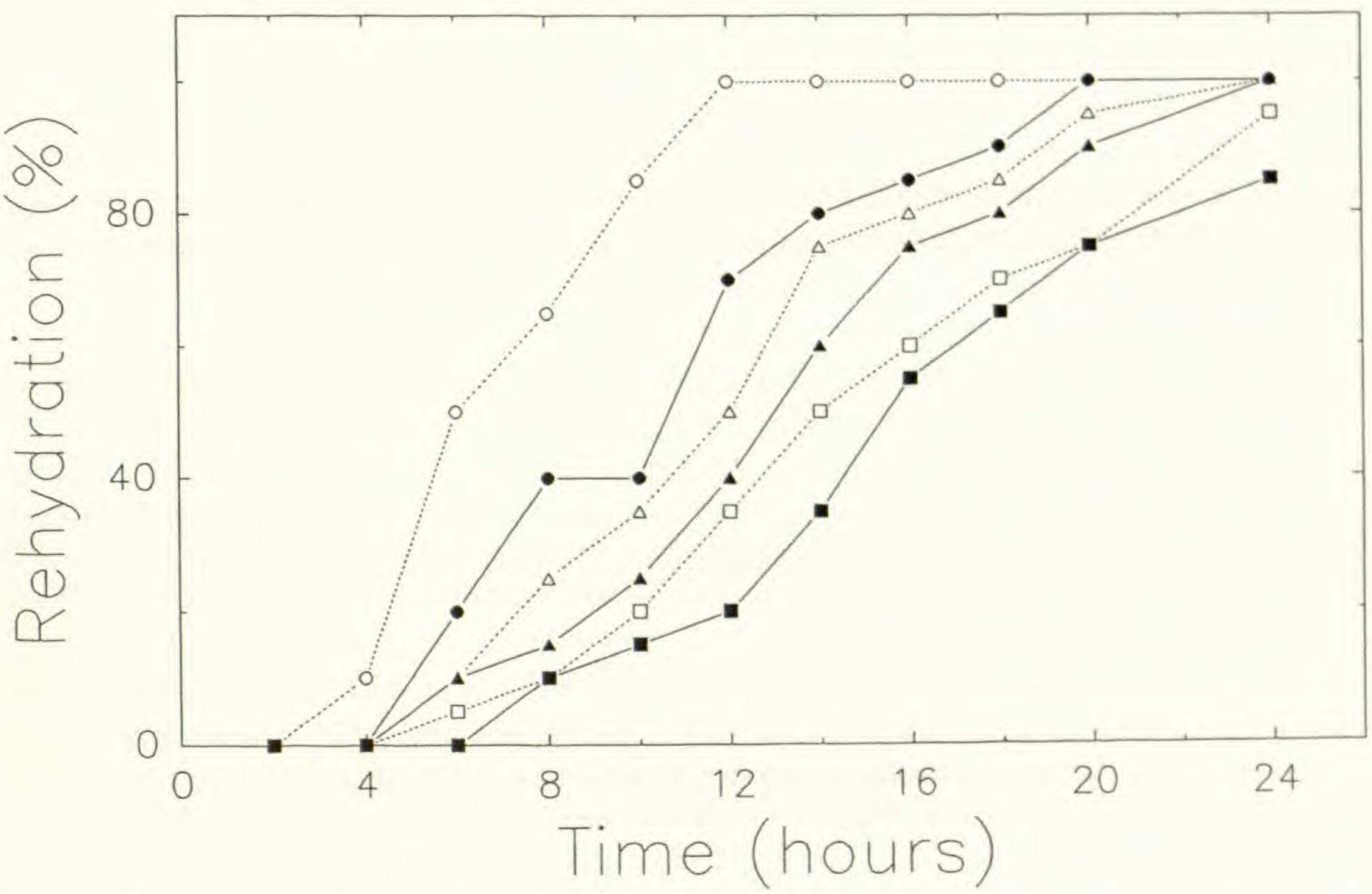

FIG. 1. Percent rehydration of fronds within treatments of 0 (○), 1 (●), 2.5 (△), 5 (▲), 10 (□) and 20 (■) ppt salinity over a 24 hour period. Mortality of plants is within treatments, as described in the text.

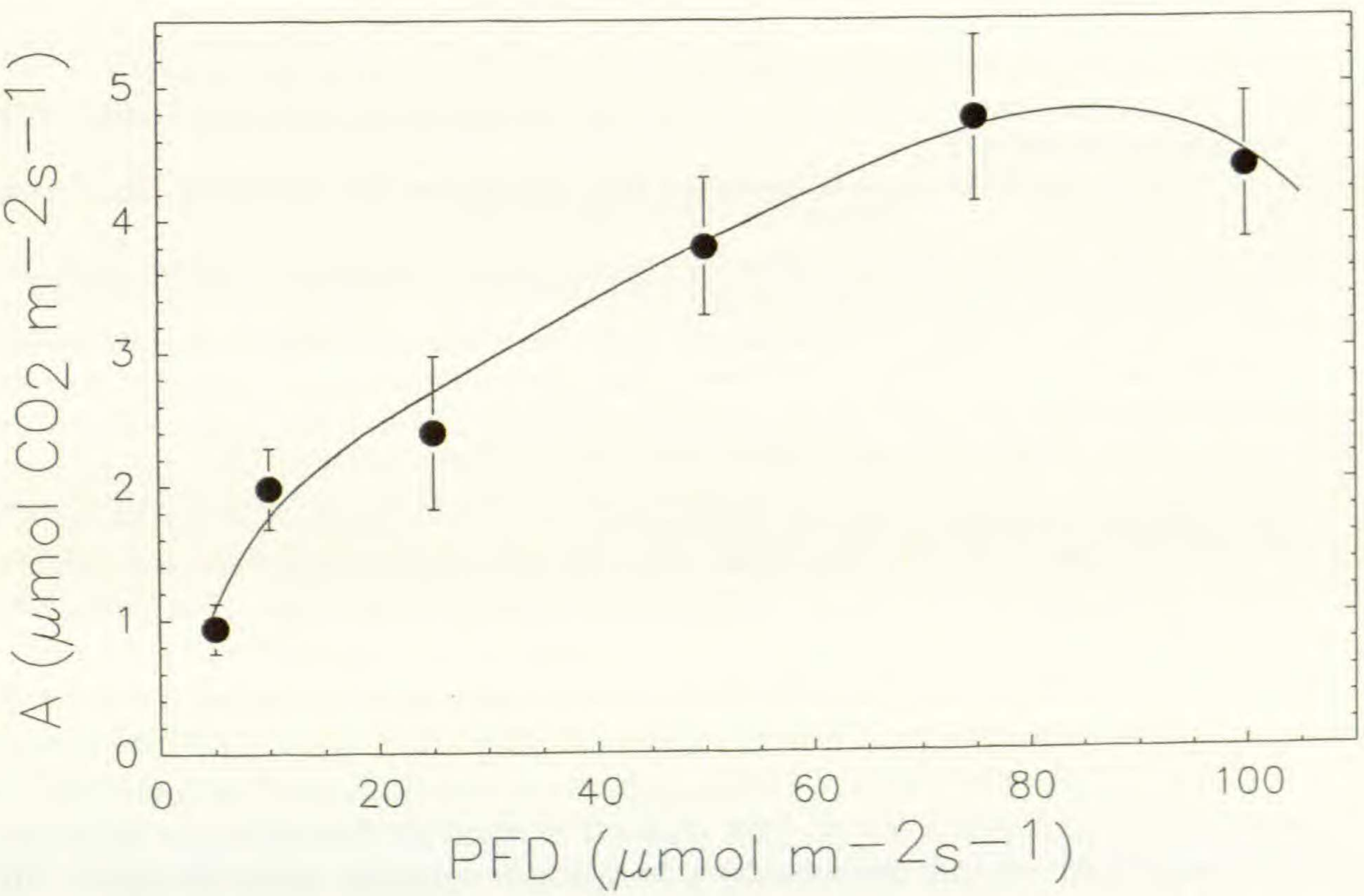

FIG. 2. Net photosynthesis (A) of *Polypodium polypodioides* in response to photon flux densities of 0 to 100 μmol m^{-2} s^{-1}.

was 50 ± 10 percent while survivorship of leaves in all lesser concentrations of salinity was 70 ± 5 percent.

Results of this study indicate that *P. polypodioides* has peak gas exchange rates which are similar to terrestrial species and is capable of peak rates within 12 hrs of the initiation of leaf rehydration. It may also take advantage of sunflecks. Furthermore, *P. polypodioides* may possesses a degree of tolerance to a range of potential salinity concentrations which may result from an inundation from storm surge. There seems to be a temporal aspect to this tolerance since prolonged exposure to salinity resulted in increased leaf mortality. Rainfall may wash remnant salt out of the root-rhizome-substrate, however, time between salt deposition and rainfall washout may greatly affect leaf and whole plant survivorship. Storm surges that are not accompanied by rainfall may cause significant damage to populations of *P. polypodioides*.

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